In the Glimpse of an Eye: Decision Making and Vision

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Outline: Vision & Decision Making

- Visual search has no memory?
  - Key Search Task by Wolfe & Horowtiz
  - Key Empirical Findings
- Psychophysical Model
  - Information Accrual Model
  - Includes Decision Making
  - Models errors and reaction time

The Search Task

- Letter Display on Screen
  - Refreshed every 111 msec
  - Contains either E or N among other letters
  - Participant response with ‘E’ or ‘N’ key press
- Display Types
  - Static: letter arrangement same on each presentation
  - Random: letters randomly rearranged for each presentation
- **Visual Attention Lab at Harvard**
  - http://search.bwh.harvard.edu/
  - Beautiful work on early visual processes
  - Striking and important results, although I disagree with *one* conclusion

The Search Task: Demo

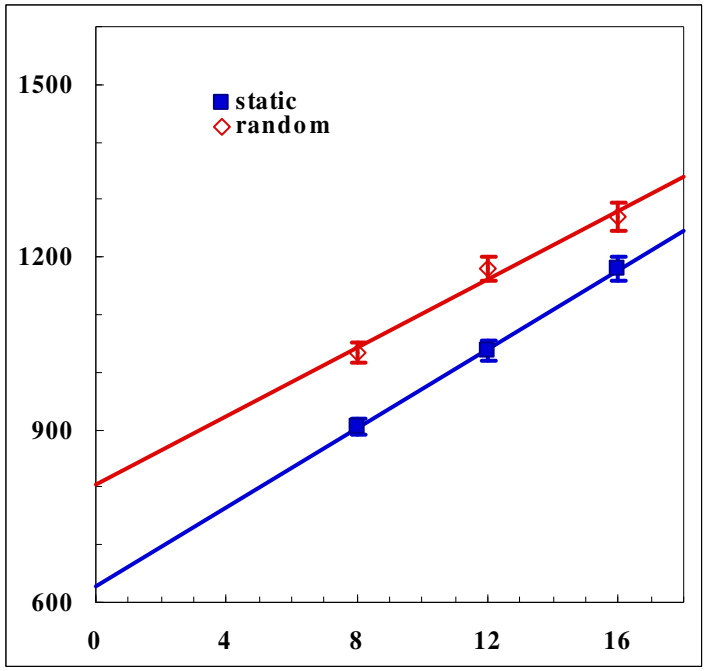
Manipulated Variables

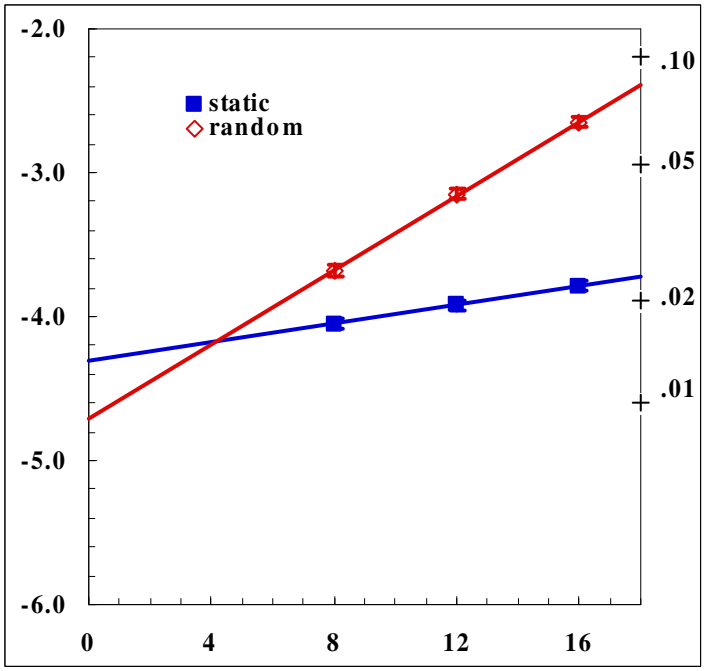
- Display type:
  - Static or Random
- Set Size
  - 8, 12, 16 letters in display, including E or N
- Eccentricity
  - Location of target relative to centre
  - On ‘ring’ 0, 1, 2, or 3

Design and Measures

- All participants performed in all conditions
  - Repeated measures design
  - 11 participants
- 480 Trials per condition
- Measures taken on each trial
  - 1: Reaction Time in msec
  - 2: Response is correct or error

Results: Effect of Set Size



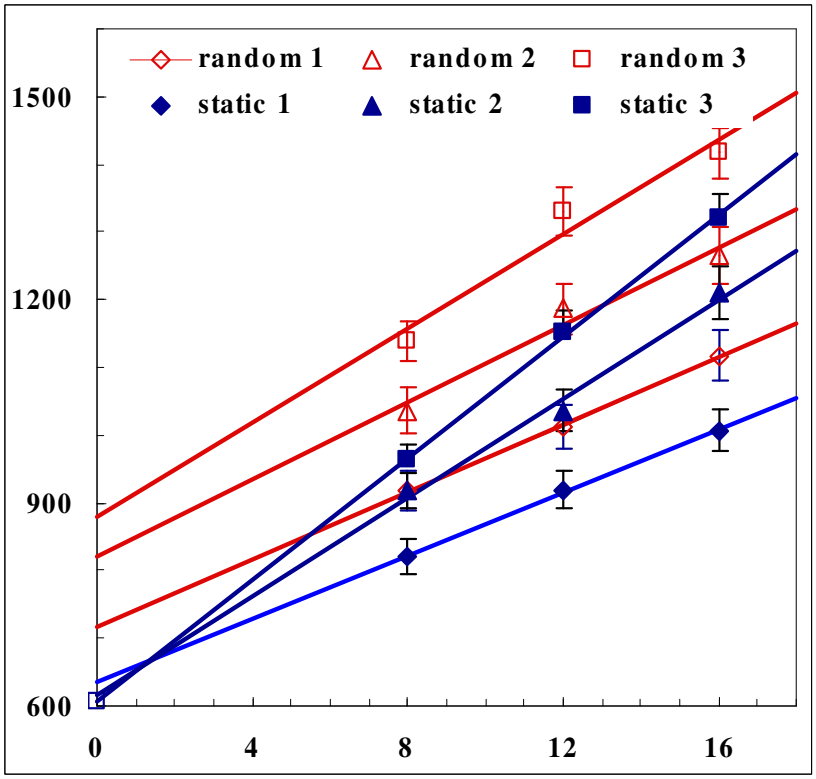


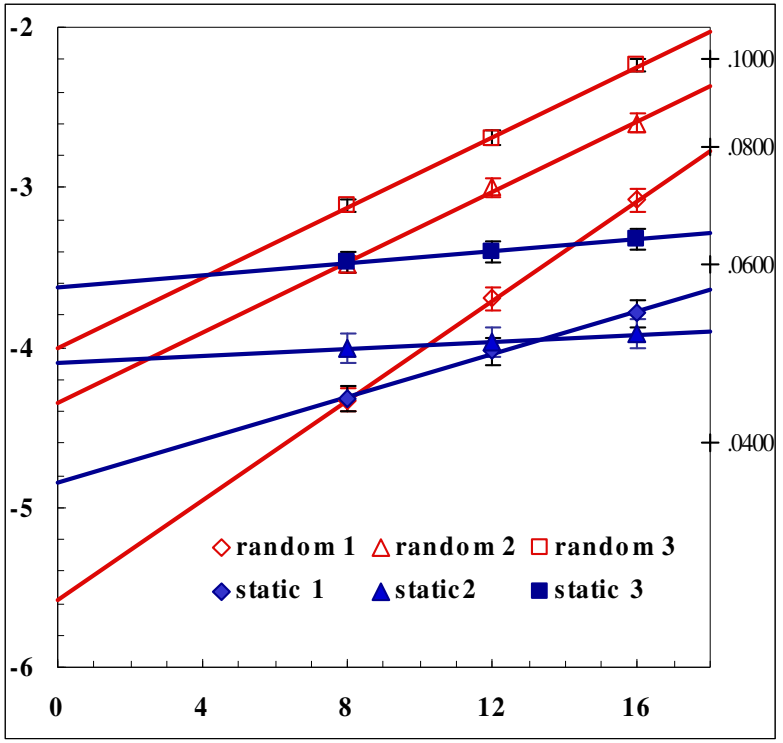
- Reaction Time: Msec
- Errors: logit left, prob right

Results: Display Type

- Reaction Time
  - Static: t = 624 + 34.7s
  - Random: t = 806 + 29.6s
  - Slope: random-static = 5.1 msec/item p = .1103
  - Intercept : random-static = 188 msec p = .0015
- Logit Error
  - Static: lgt = -4.31 + .03s
  - Random: lgt = -4.71 + .13s
  - Slope: random-static = +.13 /item p = .0042
  - Intercept: random-static = +.04 p = .3197

Results: Effect of Set Size & Eccentricity





- Reaction Time: Msec
- Errors: logit left, prob right

Results: Display and Eccentricity

- Reaction Time Slopes: All increase with set size
  - Static: Increases with eccentricity
  - Random: No effect
- Reaction Time Intercepts
  - Static: No effect
  - Random: Increases with eccentricity
- Errors as measured by logit(p(error)) Slopes
  - Static: No effect, flat with sets size
  - Random: Increases with eccentricity
- Errors as measured by logit(p(error)) Intercepts
  - Static: Increases with eccentricity
  - Random: Increases with eccentricity

Summary

- There is whacking effect of display on memory
  - Random 188 msec slower
  - Errors higher for random
  - Random, only, shows effect of set size on errors
- RT Intercepts matter
  - Similarity to classic present-absent effects
- Errors Matter
  - Different pattern to RTs
  - Need logistic regression

Problems for Theory of Visual Search

- RT slopes can be lower for random than static presentations
- RT intercepts are always higher for random than static presentations
- Error rates are independent of set size for static presentation
- Error rates increase with set size for random presentations only

A Model for Visual Search

- Information Accrual
  - Observers accumulate information for each of two possible responses in location independent accumulators, by a process such as a random walk.
  - The rate of information accumulation is inversely related to set size, *s*.
  - Consequently the time needed to achieve a fixed criterion, *C*, will be *C*s*, giving the standard linear RT versus set size function.
- Decision Criteria
  - People set a criterion for each response, and make whichever response first reaches criterion.

Decision Heuristic 1: Maintain Accuracy

- Increase criteria by amount S_V proportional to set size
  - Causes an RT *slope* increase of S_V
- BUT more distractors may ALSO mean more 'noise'
  - So greater increase in criterion for distractors.
  - Causes higher *slopes* when targets are absent
    - Often observed, but absent not necessarily 2* present slopes
- Set size *dependent* increases in criteria *may* cause set size *independent* error rates.
- Increases in decision criteria for more difficult tasks, slower information accrual, may not be able to maintain accuracy
  - So speed and accuracy *may* decline together.

Decision Heuristic 2: Fixed Criterion Increase

- : Increase criterion by I_v, independent of set size.
  - Causes an RT *intercept* change of I_V.
  - Occurs when there is loss of information over time,
    - Masking
    - Random relocation of targets
- Leads to fixed, set size independent, increase in RT, that is an increase in *intercept*

Speed-Accuracy Trade-Offs

- Perfect accuracy rare
  - Loss of information with time
- Semi-voluntary
  - ‘Neutral' trade-off depends on task difficult
  - Law of diminishing returns
- Voluntary control within limits
- Model in terms of S_v, I_v
  - S_v set size dependent criteria
  - I_v set size independent criteria

Actual Decisions

- Compromise between Heuristics
- Heuristic 1: Set size dependent criteria S_v
  - RT linear with set size
  - Errors set size independent, if successful
- Heuristic 2: Set size independent criteria I_v
  - RT intercept changes
  - Errors *increase* with set size

Ultimate Modelling Goals

- Decision Parameters from Empirical Data
  - Reaction Time Summaries, Error Rates
  - Mean, Variance, Skew, Kurtosis
- Modelling Goals?
  - Not there yet!
  - Closed form solutions not possible
  - Will need simulation

Final Summary

- Visual Search DOES have a memory
- Need RT *intercept* as well as *slopes*
- Need to model *errors* as well as *RT*s
  - Logistic Regression is Key Tool for Errors
- Modelling must include Decision Criteria
  - General approach promising
  - The devil is in the detail

Final Glimpse